

VIRUSES THAT INDUCE BREAKING IN COLOR OF FLOWER PETALS IN PANSIES AND VIOLAS¹

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INTRODUCTION

PANSIES (*Viola tricolor* var. *hortensis*) and violas, or tufted pansies (*Viola cornutus*) in California home gardens, nurseries, and seed farms frequently show a conspicuous breaking in the color of flower petals. The flowers, especially violas, are often dwarfed and malformed. Such plants are frequently stunted. An investigation was undertaken to determine the cause.

When the trouble was found to be due to two viruses—celery-calico and western-cucumber-mosaic—the method of transmission and control of the diseases were investigated. A study was made of the symptomatology on pansies and violas infected with these viruses and with common-cucumber-mosaic virus (which has not been reported in California). Experiments were also conducted with viruses known to cause breaking in flower petals of other ornamentals, to determine whether any of these would induce the disease in pansies and violas. This paper reports the results of these investigations.

A review of the literature indicates that three references to a mosaic disease in species of *Viola* in the United States have appeared. Martin³ (1926) mentions a "yellows—undetermined mosaic type" on pansy (*Viola tricolor*) in Washington, D.C. Edson and Woods (1936) report a mosaic on *Viola* sp. in the state of Washington. Perone (1939) lists pansy among twenty-nine ornamental flowering plants affected with mosaic in New Jersey, and in a general description of symptoms reports "breaking of blossoms on these host plants."

In England, Smith (1935, 1936a, 1936b, 1937) reported breaking in violas and stated that inoculation experiments "seem to show that the virus causing this variegation is a strain of cucumber-mosaic virus (cucumber virus I)." Moore (1933–1942) reported a mosaic on several pansies and violas in Somerset in 1936.

In New Zealand, Chamberlain (1936) described foliage symptoms and breaking in pansy, viola, and violet.

In New South Wales, Dunn (1941), in notes contributed by the biological branch, recorded for the first time a "mosaic (virus) of pansy (*Viola tricolor*) in Sydney, Metropolitan area."

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³ See "Literature Cited" for data on citations, referred to in the text by author and date.

MATERIALS AND METHODS

Sources of Viruses. The principal sources of the celery-calico virus were naturally infected pansies and violas. Infected pansies were collected in nurseries and gardens in Berkeley, Albany, El Cerrito, San Pablo, and Salinas. Infected Papilio, Radio, Blue Perfection, and unknown varieties of violas were obtained in Berkeley, San Pablo, and Salinas. The virus was identified by inoculating celery with the virus extract from naturally infected pansies and violas; the celery developed typical symptoms. Later, celery and other host plants were used as virus sources. The virus was maintained by repeated mechanical inoculation in and aphid transmission to pansies and violas.

The original source of most of the western-cucumber-mosaic virus used in experimental work was an infected Honey Dew melon plant (*Cucumis melo* var. *inodorus*) collected on November 7, 1932, at Keyes, in the San Joaquin Valley. The virus was maintained by repeated mechanical inoculation of various host plants, and also the virus extract was kept in cold storage at -18° C. After the experimental work was started, natural infection of pansies and violas growing in the San Joaquin Valley was demonstrated.

Common-cucumber-mosaic virus was kindly sent to me by James Johnson, University of Wisconsin.

Virus Extract. In preparation of juice from the leaves of pansies, violas, and other host plants, the leaves were washed in distilled water and ground to a pulp in a mortar. The pulp was placed in two layers of cheesecloth, a thick jellylike juice was pressed out by hand. This juice was diluted with sterile, distilled water.

Centrifugation. The diluted, extracted juice was centrifuged for 1 hour at a speed of 3,500 revolutions per minute.

Mechanical Inoculation. The carborundum method of mechanical inoculation described by Rawlins and Tompkins (1936) was used. Shortly after inoculation, the carborundum and inoculum were washed from the leaves with water.

Aphids. The methods of rearing and transferring aphids and the production of noninfective aphids have been described in a previous paper (Severin and Freitag, 1938).

CELERY-CALICO VIRUS

The celery-calico virus is a cucumber-mosaic virus which is common in the coastal fog belt and also occurs in the hot interior regions of California. Celery calico has been found in all of the large celery districts of this state (Severin and Freitag, 1938). The geographical distribution of the celery-calico virus includes California (Severin and Freitag, 1938), Washington, and Idaho (Severin, 1942a).

Transmission from Naturally Infected Host Plants. The celery-calico virus was transmitted by mechanical inoculation to pansies and violas from the following naturally infected host plants:

Chenopodiaceae:

Spinach (*Spinacia oleracea*)

Cucurbitaceae:

Cucumber (*Cucumis sativus*)

Squash (*Curcubita* sp.)

Ranunculaceae:

Perennial delphinium (hybrids and horticultural varieties)

Larkspur (*Delphinium ajacis*)

Solanaceae:

Tomato (*Lycopersicon esculentum*)

Umbelliferae:

Celery (*Apium graveolens* var. *dulce*)

Violaceae:

Pansy (*Viola tricolor* var. *hortensis*) and viola (*V. cornuta*)

The virus was recovered from a large number of naturally infected varieties of pansies and violas collected in the East Bay districts and transmitted to healthy pansies and violas grown from seeds.

Symptoms on Pansies. The foliage symptoms of celery calico on naturally infected pansies are not conspicuous in the early stages of the disease. The first symptom on the youngest leaves is a clearing of the veins and veinlets. The youngest leaves are dwarfed and malformed. When a large number of infected pansies are examined, an occasional plant shows typical symptoms resembling celery calico (Severin and Freitag, 1938). Some of the older leaves of such a pansy are amber yellow except for small green areas enclosed in yellow veins and veinlets. In the later stages of the disease, the plant turns yellow. Young infected plants are stunted with shortened internodes and plants finally die.

The color changes involved in breaking of flower petals vary according to the normal color of the pansies. Red varieties develop red streaks, which later become yellow and then white. Purple varieties show purple streaks and later white streaks. Dark-blue and pale-blue varieties develop dark-blue and pale-blue streaks followed by white streaks. So-called black varieties show black streaks, which turn purple, and then white. All of the petals may show breaking, or all but the lowest, or only the two upper petals.

Pansies infected in the flats, when transplanted in the home gardens, develop malformed and dwarfed flowers. Pansies infected when older may continue to blossom and develop ruffled flowers or flowers with the margins rolled inward. Frequently breaking occurred on one or more branches while on other stems on the same plant the flowers were normal.

A brief description of the early and late symptoms on flowers of varieties of French bedding pansies follows:

Adonis: Purple streaks appear on the upper two petals and on the margins of the remaining petals; later, the purple streaks become white on the pale-blue flower.

Victoria: The petals show pale-red streaks; later, turn yellow, and then white.

Emperor William: The petals develop dark-blue streaks, which later become white and are more pronounced on the lower surface of the dark navy-blue flower.

King of the Blacks: The petals first show black streaks, which become purple. Blotches of purple appear on the petals; later, the streaks become white.

Light Blue: Pale-blue streaks alternating with white streaks occur on all petals; later, the two upper petals become blanched.

Lord Beaconsfield: The two upper petals are white with purple streaks on the lavender, heliotrope, and purple flowers.

Prince Henry: Purple and white streaks occur on the two upper petals, which later become blanched on the dark-blue flower.

Breaking in color of the flower petals in varieties of Giant Mastodon pansies are briefly described as follows:

Geneva Giant mixed: Short yellow or white streaks occur in the margin of the petal of the many-colored flowers.

Madame Steele: White streaks or bands appear on the two lateral and the lowest petals. The flowers are malformed.

Sea Blue: Numerous short white streaks develop on all petals.

Vulcano: Yellow alternating with red streaks occur on the petals.

Swiss Giant pansies inoculated with the virus showed the following symptoms on the flowers:

Dark Blue: Short white streaks occur on all petals.

Dark Red: The early flower symptoms consist of a few yellow streaks alternating with dark red; later white streaks alternate with pale-red streaks.

Lake of Thun, or Ullswater: White streaks appear on all petals, and later, blanching occurs on the blue flower with a blue-black center.

Infected Mastodon Jumbo pansies show a wide range of colors, shades, and markings (plate 1). The golden-yellow strains develop yellow streaks which later become white. Infected blue and yellow Jumbo pansies have blue, purple, and yellow bands. The brown pansy shows yellow and brown bands. The purple strain shows pale- and dark-purple streaks. White streaks appear on the petals of the blue strain.

Symptoms on *Violas*. When *Papilio viola* was inoculated with the sap expressed from perennial delphinium naturally infected with the celery-calico virus, the earliest foliage symptom was a clearing of the veinlets usually appearing at the base of the youngest leaves (plate 2, *B*) and sometimes spreading to the remaining portion of the leaves (plate 2, *C*). Later small chlorotic circular areas (plate 2, *D*) sometimes appear on the younger leaves. The oldest leaves develop lemon-yellow blotches (plate 2, *E*) which coalesce and spread over the entire leaves (plate 2, *F*). In the advanced stage of the disease, the plants are stunted with short upright stems bearing thick, linear leaves, frequently mottled with dark-green areas.

Of all varieties of *violas* examined in nurseries, *Papilio violas* show the most severe breaking in the color of the petals (plate 3, *B*). The flowers are dwarfed and malformed, with numerous white streaks (plate 3, *C*).

An intensive study was made of breaking in the petals of *Radio viola*. Conspicuous white streaks appear on some flowers (plate 4, *B*), followed by blanching with a few streaks of the normal color of the flower (plate 4, *C, D, E*) and finally the flower becomes pale blue (plate 4, *F*) and then white without streaks. Blotching may appear on some flowers (plate 4, *G, H*), followed by streaking (plate 4, *I, J*), and blanching (plate 4, *K*). The flowers may be dwarfed, malformed, and have white streaks (plate 4, *L*).

In some varieties of *violas*, the first symptom to appear is white streaks. In other varieties, the streaks are paler than the normal color of the variety. Blotches of white often appear in the normal color. Blanching of the flowers frequently occurs, with pale streaks or bands of the normal color.

A brief description of breaking in varieties of *violas* inoculated with celery calico follows:

Blue Perfection: White streaks occur on all petals.

Chantreyland: The apricot petals show pale-yellow streaks on the upper and lateral petals.

Heavenly Blue: White streaks appear on the petals; later, the petals become pale blue and then white.

Jersey Gem: A slight breaking in color of the violet-purple petals occurs.

Lilac: White streaks appear on all petals; later, the petals become blanched with purple streaks.

Tufted "Pansy Violet": The flowers are dwarfed.

Papilio: Numerous white streaks develop on the blue petals (plate 3, *B*). The flowers are frequently dwarfed and malformed (plate 3, *C*).

Papilio Violet Lilac: White streaks occur on all blue petals.

Purple King: Pale-purple streaks develop in the pale-purple color of the flower.

Radio: Blotches of white with pale-blue streaks appear on the blue petals (plate 4, *G, H, I, J, K*); later, white streaks occur between the veins (plate 4, *B, L*) and finally the pale-blue streaks along the veins become broken (plate 4, *C, D, E*), and then disappear, and the petals become pale blue (plate 4, *F*) or white.

Rose Queen: White streaks and bands occur on all petals.

Royal Blue: Pale-blue streaks develop on the petals.

Recovery of Virus. The celery-calico virus was recovered from experimentally infected varieties of pansies and violas (with one exception) by mechanical inoculation of the extracted, centrifuged juice into celery and cucumbers. (The virus was transferred more readily to cucumbers than to celery.) Jersey Gem violas infected with celery-calico virus developed breaking in color of the flower petals, but numerous attempts made to recover the virus by mechanical inoculation yielded negative results.

WESTERN-CUCUMBER-MOSAIC VIRUS

Western cucumber mosaic occurs only in the interior regions of California and not in the coastal fog belt.

Transmission from Naturally Infected Host Plants. The host plants naturally infected with western-cucumber-mosaic virus include the following plants in four families:

Chenopodiaceae:

Sugar beet (*Beta vulgaris*)

Swiss chard (*Beta vulgaris* var. *cicla*)

Spinach (*Spinacia oleracea*)

Cucurbitaceae:

Cucumber (*Cucumis sativus*)

Honey Dew melon (*Cucumis melo* var. *inodorus*)

Solanaceae:

Tomato (*Lycopersicon esculentum*)

Umbelliferae:

Celery (*Apium graveolens* var. *dulce*)

Symptoms on Pansies. The symptoms of western cucumber mosaic on pansies and violas cannot be distinguished from those induced by the celery-calico virus. The identity of each virus can only be determined by symptoms produced on other host plants.

A brief description of breaking in color of flower petals in varieties of French bedding pansies follows:

Adonis: The veins of the two upper and two lateral petals are purple with ashy-gray interveinal areas on the pale-blue flowers.

Emperor William: Numerous white streaks develop in the dark navy-blue petals.

King of the Blacks: Usually purple bands alternating with black streaks appear on the petals.

Light Blue: The veins are pale blue, with interveinal white areas; later the upper petals become blanching and all petals are ruffled.

Lord Beaconsfield: The two upper petals become blanching with purple veins, white blotches appear on the two lateral petals with purple veins, and a white blotch appears at the basal central margin, with purple veins near the margin of the basal petal of the lavender, heliotrope, and purple flower.

Prince Henry: The dark-blue flowers usually show diffuse blue streaking or blotches on all petals when severely affected by the disease. Such flowers are dwarfed, and their petals are curled, with the margins rolled inward.

The symptoms on varieties of Giant Mastodon pansies inoculated with the western-cucumber-mosaic virus follow:

Giant Geneva mixed: White streaks appear on the petals of the many-colored flowers.

Light Blue: The upper petals become blanching; on all other petals the veins are pale blue with interveinal white areas. The blossoms are dwarfed with ruffled petals.

Madame Steele: White streaks develop on the petals.

Sea Blue: White streaks are occasionally conspicuous on the lower surface of the flower; other flowers on the same plant may be normal.

Vulcano: Yellow streaks alternating with red streaks occur on the upper two petals.

The symptoms on inoculated Swiss Giant pansies are as follows:

Dark Blue: The petals develop white streaks, and the margins are rolled inward.

Dark Red: Yellow or white streaks appear on the upper and lateral petals.

Lake of Thun: The petals show white streaks and later blanching (plate 5, *H*) on the blue flower with a black center.

Symptoms on Violas. The symptoms on inoculated varieties of violas, briefly described, are as follows:

Blue Perfection: The flowers are dwarfed with white streaks on all petals.

Chantreyland: The upper and lateral petals of this apricot variety fade to a yellow color with a few white streaks on the upper petals.

Heavenly Blue: White blotches followed by white streaks appear on the upper petals and white bands on the lateral petals (plate 5, *B*).

Jersey Gem: The margins of the petals are curled inward, and a few white streaks may appear on the violet-blue petals.

Lilac: White streaks develop on the petals, and later blanching (plate 5, *E, J*).

Papilio: White blotches, streaks, and bands occur on the blue petals. The flowers are dwarfed, with the margins of the petals curled inward. The symptoms induced by the western-celery-mosaic and celery-calico viruses are identical on this variety of viola since all gradations of blotches, streaks, and bands occur on plants infected with these viruses.

Papilio Violet Lilac: White streaks occur on all petals.

Purple King: Dark-purple streaks appear with interspaces or blotches of pale purple. The deep-blue flowers are dwarfed with the two upper and lower petals cupped inward.

Rose Queen: The flowers are dwarfed with short white streaks on the petals.

Tufted "Pansy Violets": The plants are difficult to infect by mechanical inoculation and rarely does a flower show breaking (plate 5, *D, G*). The virus was rarely recovered; only 1 of 30 Zucchini squash plants developed symptoms of western cucumber mosaic with six virus extractions.

Recovery of Virus. The virus of western cucumber mosaic was readily recovered from all varieties of pansies, with the exception of Adonis, by inoculating cucurbits, but difficulty was experienced in recovering the virus

from violas. Although no symptoms were observed on Victoria Blood Red pansy, the virus was recovered. The virus was recovered from all varieties of violas, after many trials with some varieties, and transferred to cucumbers and Zucchini squash.

COMMON CUCUMBER MOSAIC

Common cucumber mosaic is a destructive disease of cucumbers and other host plants in middle western and eastern United States, but is not known to occur in California.

In many of the varieties of pansies and violas tested, no flower symptoms appeared even though repeated inoculations were made with both infected cucumbers and *Nicotiana glutinosa* as sources of virus. The virus was not recovered from such plants.

Symptoms on Pansies. The first symptom to appear on some varieties of pansies and violas is a clearing of the veins and veinlets on the youngest leaves. Later, infected plants are stunted with shortened internodes. The older leaves are mottled and the younger leaves are small and narrow and turn yellow in the later stage of the disease. A brief description of flower breaking in varieties of inoculated pansies follows:

Lord Beaconsfield: The petals show dark-purple streaks with pale-purple bands between them on the lavender, heliotrope, and purple flower.

Madame Steele: Pale-purple streaks develop which appear as white streaks on the lower surface of the petals.

Lake of Thun, or Ullswater: Short white streaks appear on the buds and on all petals after the bud expanded (plate 6, *D*) of the blue flower with a blue-black center.

Symptoms on Violas. A brief description of breaking in inoculated varieties of violas follows:

Chantreyland: The apricot flowers are dwarfed (plate 6, *C*) frequently with pale, yellow, ruffled upper and lateral petals.

Papilio: White streaks appear on upper and lateral pale-blue petals.

Papilio Violet Lilac: White streaks appear on upper and lateral pale-blue petals; the margins are frequently rolled inward.

Heavenly Blue: The blue petals become blanched with a few pale-blue blotches and streaks (plate 6, *B*).

Purple King: Pale-purple blotches and streaks develop in the normal deep-blue color of the flower.

Recovery of Virus. Common-cucumber-mosaic virus was recovered and transferred to cucumbers, to *Nicotiana glutinosa*, or to Turkish tobacco (*N. tabacum*) by mechanical inoculation from only eight varieties of pansies and violas showing breaking as follows: Lord Beaconsfield, Prince Henry, Lake of Thun (Ullswater), Madam Steele, Chantreyland, Papilio, Papilio Violet Lilac, and Purple King. The virus was recovered from Tufted "Pansy Violet", Prince Henry, and Victoria, though they showed no symptoms. Repeated failures were obtained in attempts to recover the virus from the following varieties of pansies which showed breaking: Adonis, Emperor William, Geneva Giant mixed, King of the Blacks, Blue Perfection, and Heavenly Blue.



Fig. 1.—China aster (*Callistephus chinensis*) infected with the virus of spotted wilt: upper, leaves showing necrosis; lower, petals showing breaking in color.

VIRUSES CAUSING BREAKING IN OTHER FLOWERS

As reported by Tompkins (1939), the author demonstrated that the false cabbage or turnip aphid, *Lipaphis pseudobrassicae* (Davis) is the vector of mild and severe mosaic viruses in annual stock, or gilliflower (*Matthiola incana* var. *annua*) in nature. Experimental transmission was obtained in greenhouse tests with this species of aphid, and also with the cabbage aphid, *Brevicoryne brassicae* Linnaeus, and the green peach aphid, *Myzus persicae* (Sulzer).

The false cabbage or turnip aphid was used in tests to determine whether the mild-mosaic virus induces breaking in violas. Noninfective, mature, wingless aphids reared on mild-mosaic stock plants were transferred in lots of 20 aphids to each of 5 Blue Perfection, 5 Ruby, 5 White Eye violas, and 5 stock plants. Breaking occurred only in the stock plants.

Since the lily aphid, *Myzus circumflexus* (Buckton) is a vector of the celery-calico virus, tests were made with this aphid to determine whether this virus causes breaking in annual stock plants. Mature, wingless aphids reared on Papilio violas infected with celery-calico virus were transferred in lots of 20 aphids to each of 10 healthy stock plants, but no breaking occurred.

The virus extract prepared from stock plants infected with mild mosaic was mechanically inoculated into 5 Blue Perfection violas, 5 Papilio violas, and 5 stock plants. Breaking occurred only in the stock plants.

The virus extract from Papilio violas infected with celery calico was mechanically inoculated in 5 Papilio violas and 5 stock plants. Breaking occurred in the violas but not in stock plants.

Tomato-spotted-wilt virus induced breaking of China asters (*Callistephus chinensis*) (fig. 1), but this virus failed (in mechanical-inoculation experiments) to cause breaking in Papilio violas grown from seeds and Radio violas from cuttings. Celery-calico virus from infected violas failed to induce breaking in China asters.

APHID TRANSMISSION OF VIRUSES

The other paper in this issue (Essig, 1947) discusses the characters, distribution, and food plants of aphid species which have been reported on pansies and violas under natural conditions. Five of these that occur in California were tested to determine whether they transmit celery-calico virus to pansies and violas, and three were tested with western-cucumber-mosaic virus. Some aphids that breed on celery but have not been reported on pansies and violas under natural conditions were also tested for transmission of celery-calico virus.

Vectors of Celery-Calico Virus. The following species of aphids, which have been reported to occur on pansies and violas, or tufted pansies, under natural conditions, were demonstrated to be vectors of the celery-calico virus from infected pansies, violas, and celery to pansies and violas:

Cotton or melon aphid, *Aphis gossypii* Glover

Lily aphid, *Myzus circumflexus* (Buckton)

Foxglove aphid, *Myzus solani* (Kaltenbach)

Violet aphid, *Micromyzus violae* (Pergande)

The celery-calico virus was transmitted from celery to pansies and violas by the following aphid species, which breed on celery under natural conditions (see Essig, 1938) :

Celery leaf aphid, *Aphis apigraveolens* Essig
 Celery aphid, *Aphis apii* Theobald (*A. helianthi* Monell?)⁴
 Rusty-banded aphid, *Aphis ferruginea-striata* Essig
 Erigeron root aphid, *Aphis middletonii* Thomas
 Yellow willow aphid, *Cavariella capreae* (Fabricius)
 Green peach aphid, *Myzus persicae* (Sulzer)
 Honeysuckle aphid, *Rhopalosiphum conii* (Davidson)

Vectors of Western-Cucumber-Mosaic Virus. The following species of aphids are vectors of the western-cucumber-mosaic virus :

Cotton or melon aphid, *Aphis gossypii* Glover
 Bean or dock aphid, *Aphis rumicis* Linnaeus
 Green peach aphid, *Myzus persicae* (Sulzer)

INSECTS WHICH FAILED TO TRANSMIT CELERY-CALICO VIRUS

Severin (1943) reported breaking in color of flower petals of phlox (*Phlox drummondii*) induced by the California aster-yellows virus transmitted by the short-winged aster leafhopper, *Macrostoteles divinus* (Uhler) and the long-winged aster leafhopper, a biological race of the same species (Severin, 1940). Tests were made to determine whether either of these could transmit the celery-calico virus. Sixteen lots of 25 or 35 noninfective males of each vector were fed for 2 days on *Papilio violas* infected with celery-calico virus, and then each lot was transferred to a healthy *Papilio viola* grown from seeds. No breaking occurred in the 16 plants exposed to the leafhoppers.

CONTROL

Field investigations were carried on for the past twelve years to determine the source of the celery-calico-virus infection in pansies and violas and the spread of this disease in home gardens. Many retail nurseries were visited in the East Bay districts, and it soon became evident that nurserymen who do not spray to control aphids on pansies and violas disseminate the disease to home gardens by selling infected plants. In one retail nursery all of the flats containing *Papilio violas* showed breaking and the plants were covered with aphids. When the flats were removed from the racks and the violas were allowed to dry in the nursery, the infective aphids spread to pansies, violas, other susceptible ornamental host plants, and weeds. Home gardeners should avoid purchasing pansies and violas showing breaking and aphid infestation.

One nurseryman made cuttings from the perennial Radio viola. An examination of the cuttings in the greenhouse showed breaking in a high percentage. This nurseryman rogued all of the diseased Radio violas grown out of doors and sprayed weekly to control the aphids. The following year not a single cutting showed breaking in the flowers in the greenhouse.

The recommendation for controlling celery calico and western cucumber mosaic in pansies and violas is to spray these plants and susceptible economic

⁴ According to E. O. Essig (personal interview), *Aphis apii* may be identical with *A. helianthi*.

plants weekly until the vegetation on the foothills becomes dry, since many species of aphids fly from the foothills. The spray should be applied to the lower surface of the leaves, those which spread on the ground being raised with the fingers. During the summer, spraying can be discontinued, since aphids do not multiply during hot weather. All pansies and violas showing breaking should be rogued and burned. Avoid purchasing pansies and violas showing breaking and aphid infestation.

The insecticide which gave satisfactory results to control aphids was three teaspoons of Black Leaf 40 to a gallon of water, with Volek or soap used as an adherent.

SUMMARY

The symptoms induced by three cucumber-mosaic viruses which cause breaking in color of flower petals of varieties of pansies (*Viola tricolor* var. *hortensis*) and violas, or tufted pansies (*V. cornuta*) are described in this paper. Of these cucumber-mosaic viruses, celery calico and western cucumber mosaic occur in California, but common cucumber mosaic is not known to occur here. Celery calico is common in the coastal fog belt and also occurs in the hot interior regions of California. Western cucumber mosaic occurs only in the interior regions of California and not in the coastal fog belt.

The following species of aphids which have been reported to occur on pansies and violas under natural conditions were demonstrated to be vectors of the celery-calico virus:

Cotton or melon aphid, *Aphis gossypii* Glover
Lily aphid, *Myzus circumflexus* (Buckton)
Foxglove aphid, *Myzus solani* (Kaltenbach)
Violet aphid, *Micromyzus violae* (Pergande)

Infections of pansies and violas with celery-calico virus were obtained with the following aphid species, which breed on celery under natural conditions and also transmit the celery-calico virus to this host plant:

Celery leaf aphid, *Aphis graveolens* Essig
Celery aphid, *Aphis apii* Theobald (*A. helianthi* Monell?)
Rusty-banded aphid, *Aphis ferruginea-striata* Essig
Erigeron root aphid, *Aphis middletonii* Thomas
Yellow willow aphid, *Cavariella capreae* (Fabricius)
Green peach aphid, *Myzus persicae* (Sulzer)
Honeysuckle aphid, *Rhopalosiphum conii* (Davidson)

The following species of aphids have been proved to be vectors of the western-cucumber-mosaic virus:

Cotton or melon aphid, *Aphis gossypii* Glover
Bean or dock aphid, *Aphis rumicis* Linnaeus
Green peach aphid, *Myzus persicae* (Sulzer)

Aphids transmitting the viruses of celery calico and western cucumber mosaic to pansies and violas can be controlled by using a Black Leaf 40 spray.

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Plate 1. Jumbo pansy (*Viola tricolor* var. *hortensis*) naturally infected with celery calico virus: top row, Golden Yellow strain, the left showing yellow streaks, the right, white streaks; center row, left, blue and yellow pansy with blue, purple, and yellow bands; center row, right, brown pansy with yellow and brown bands; bottom row, left, purple strain showing pale- and dark-purple streaks; bottom row, right, blue pansy showing white streaks on the petals.

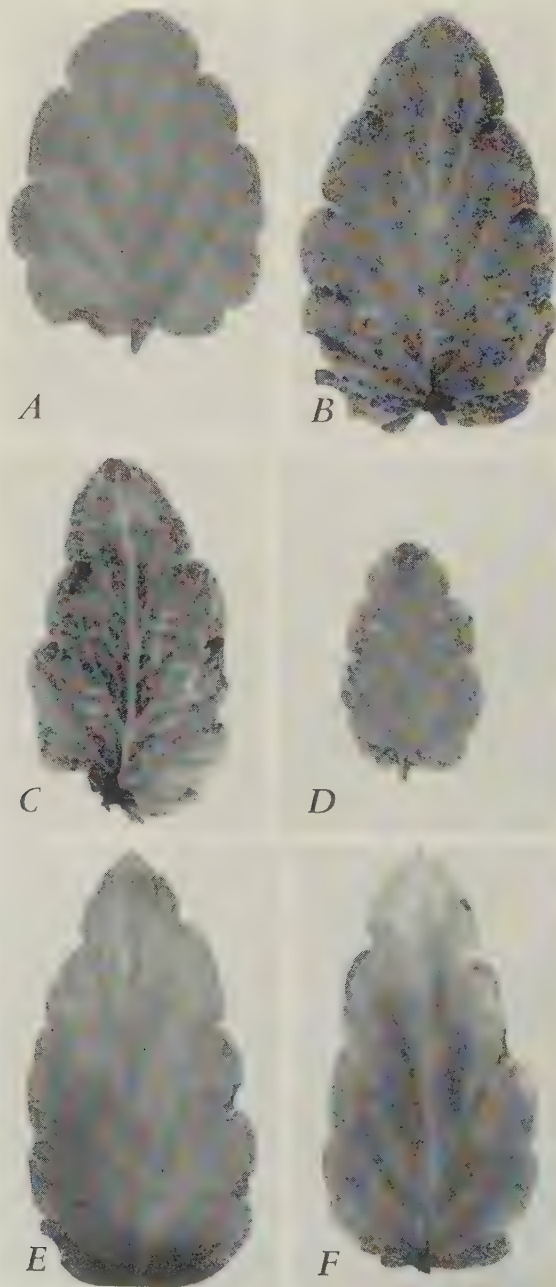


Plate 2. Symptoms of celery calico on the leaves of *Papilio viola* (*Viola cornuta*): *A*, leaf from healthy check or control plant; *B*, cleared venation on basal half of leaf; *C*, cleared veins and veinlets on entire leaf; *D*, small, chlorotic, circular areas; *E*, yellowing of leaf; *F*, lemon-yellow at tip and margin of leaf.

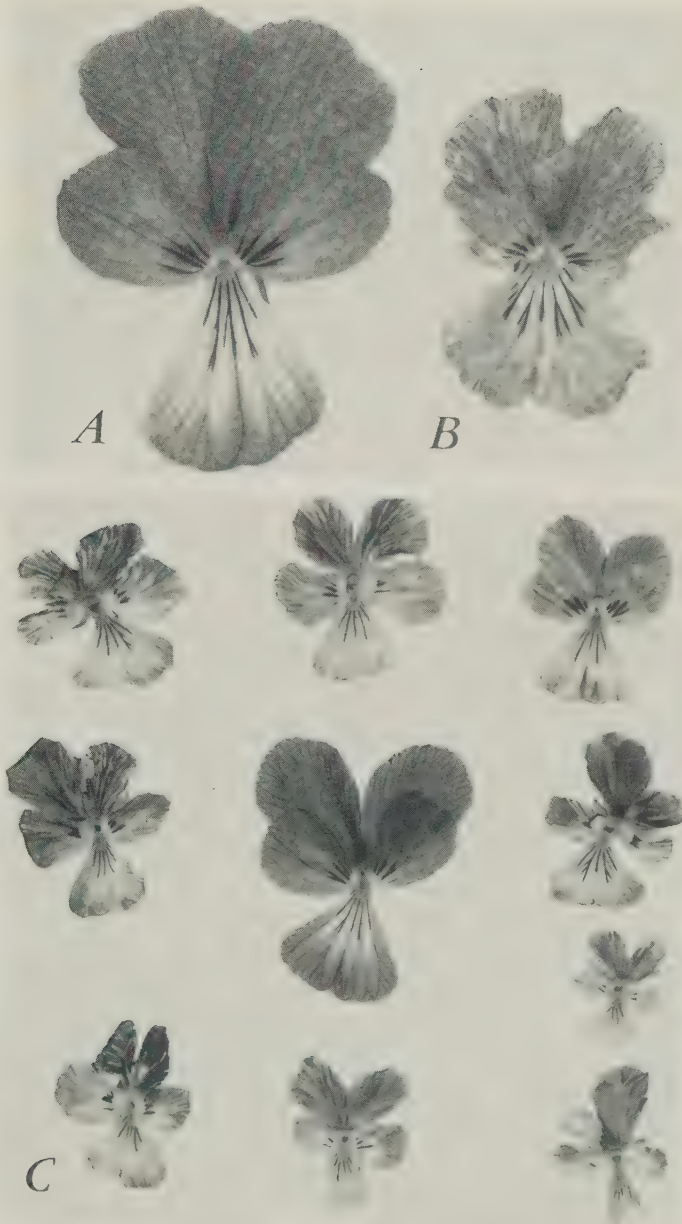


Plate 3. Breaking in color of flower petals of *Papilio viola* (*Viola cornuta*): A, flower from healthy plant; B, flower showing white streaks on petals, from a plant inoculated with the virus extract from perennial delphinium naturally infected with celery calico collected at Colma November 6, 1937; C, center: normal flower from a healthy plant. Grouped around it are dwarfed flowers showing breaking in the color of the petals, from plants naturally infected with the celery-calico virus. (El Cerrito, May 29, 1935).



Plate 4. Radio viola (*Viola cornuta*) showing breaking in color of petals from plants naturally infected with aster callosity virus: A, flower from healthy plant; B, flower showing white streaks; C, D, E, successive stages in blanching with few streaks of normal color of flower; F, blanching flower showing no streaks (Berkeley, August 23, 1934); G, H, I, J, K, blanching and streaking; L, dwarfed flower showing white streaks (Berkeley, June 16, 1936).

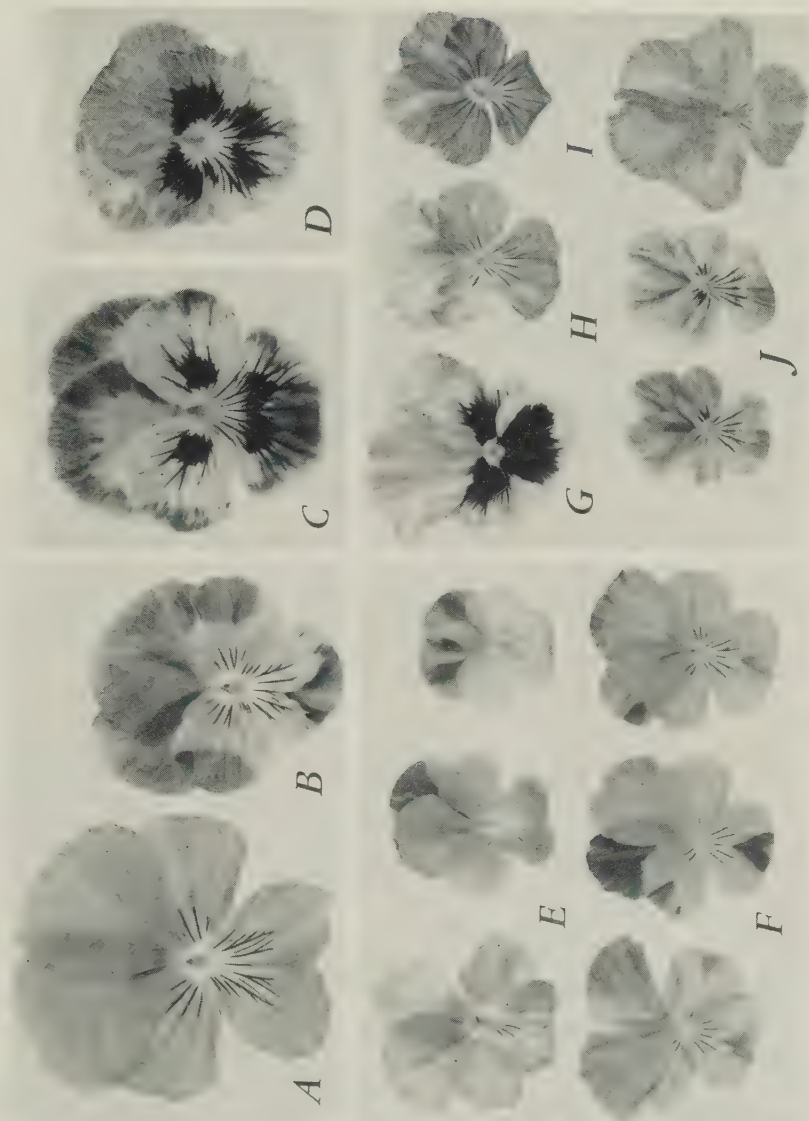
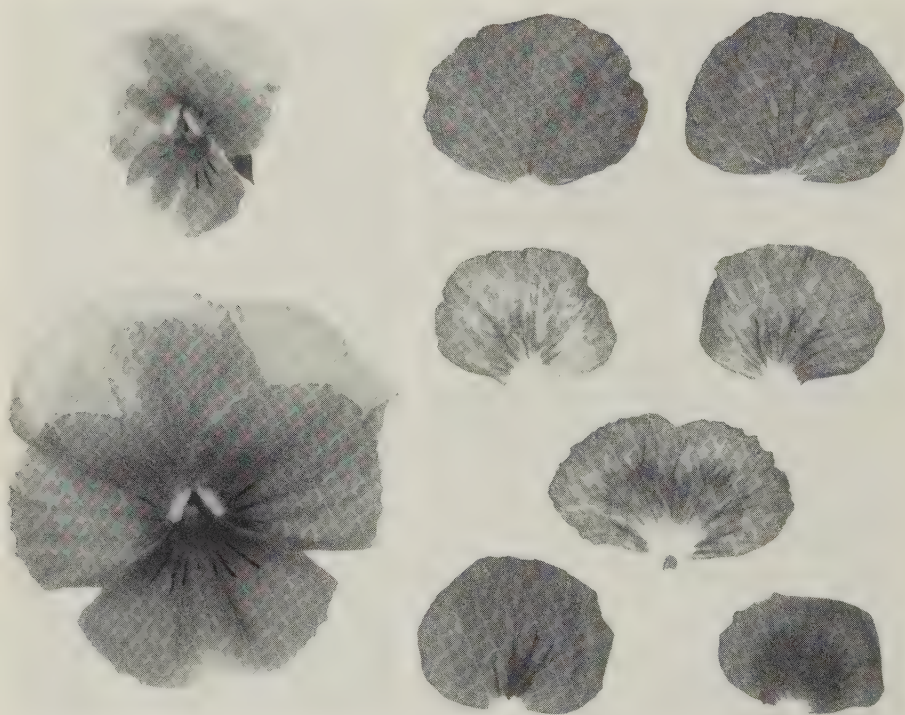


Plate 5. Tufted pansies or violas (*V. cornuta*) showing breaking in color of flower petals induced by western-cucumber-mosaic virus (B, D, F, G, H, I) and celery-calico virus (E, J). A, B, Heavenly Blue viola, A showing normal flower from healthy plant and B, a dwarfed flower from infected plant with normal, deep-blue color on upper petals and deep-blue blotches and pale-blue center on lateral and lowest petals; C, Tufted "Pansy Violet" showing normal flower from check or control plant; D, dwarfed flower with irregular margin showing numerous white streaks on petals; E, Lilac viola, flowers from plant inoculated with celery-calico virus; F, blossoms from plant inoculated with western-cucumber-mosaic virus showing dwarfing and stages of blanching of petals; G, Tufted "Pansy Violet" showing white streak and early blanching; H, Lake of Thun, or Ullswater pansy, dwarfed flower showing blanching; I, normal flower from check or control plant; J (lower row), Lilac viola, showing blanching and white streaks.



A

B



C

D

Plate 6. Pansy (*Viola tricolor* var. *hortensis*) and tufted pansy, or viola (*V. cornuta*) showing breaking in color of flower petals induced by common-cucumber-mosaic virus: A, B, Heavenly Blue viola, A showing normal flower from healthy check or control; and B, blanching petals with a few pale, blue blotches and streaks; C, Chantreyland viola, upper, dwarfed flower showing white blotches; lower, normal flower from healthy plant; D, Lake of Thun, or Ullswater, pansy, upper five petals showing short white streaks; lower, two petals from check or control plant.

APHIDS FEEDING ON VIOLACEOUS PLANTS
IN CALIFORNIA

E. O. ESSIG

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APHIDS FEEDING ON VIOLACEOUS PLANTS IN CALIFORNIA¹

E. O. ESSIG²

PANSIES (*Viola tricolor* var. *hortensis*) and violas, or tufted pansies (*V. cornuta*) in California are subject to two virus diseases, celery calico and western cucumber mosaic. These diseases are treated in a companion article (Severin, 1947).³ The vectors are aphids, or plant lice. Celery calico was first investigated (Severin and Freitag, 1938) as a disease of celery. There are no less than ten aphid species feeding on celery in California. Other species which ordinarily do not feed and propagate on this host may also transmit the celery-calico virus under experimental conditions.

The only species apparently restricted to violaceous plants in this state and in other parts of North America is the common violet aphid, *Micromyzus violae* (Pergande). Nine additional species have been recorded as feeding on *Viola* spp. (Patch, 1938) in various parts of the world.

The purpose of this paper is to furnish those interested in the virus diseases of plants, particularly of ornamental violas and pansies, pertinent information concerning the aphid vectors of these diseases. Certain of these aphids have previously been discussed in relation to celery calico as a disease of celery in California (Essig, 1938a); and therefore the treatment of these particular aphid species excludes detailed descriptions and emphasizes more particularly synonymy, host plants, distribution, and bibliography.

It is expected that the illustrations may enable those interested in this problem to identify the aphids responsible for the dissemination of the celery-calico and western-cucumber-mosaic viruses.

THE PEA APHID

- Macrosiphum pisi* (Kaltenbach)
- Aphis pisi* Kaltenbach (1843, p. 23-24)
- Aphis ulmariae* Schrank (1801, p. 116-17)
- Aphis onobrychis* B. de Fonscolombe (1841, p. 61)
- Adactynus pisi* (Kaltenbach) (Rafinesque 1819, p. 18)
- Siphonophora corydalis* Oestlund (1886, p. 25-26)
- Nectarophora destructor* Johnson (1900, p. 58-59)
- Macrosiphum trifolii* Pergande (1904, p. 21-23, fig. 4)
- Illinoia pisi* Wilson (1910 b, p. 318)
- Acyrtosiphon onobrychis* (B. de Fonscolombe)

The pea aphid is one of the largest and most conspicuous economic aphids. Its all-green color and its propensities for leguminous plants make it easily recognized. In common with many other aphids, this species drops to the ground when the host plants are disturbed, a habit that often enables the individuals to conceal themselves under clods of earth and debris and thus escape

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³ See "Pertinent Literature," at the end of this paper, for complete citations, referred to in text by author and date.

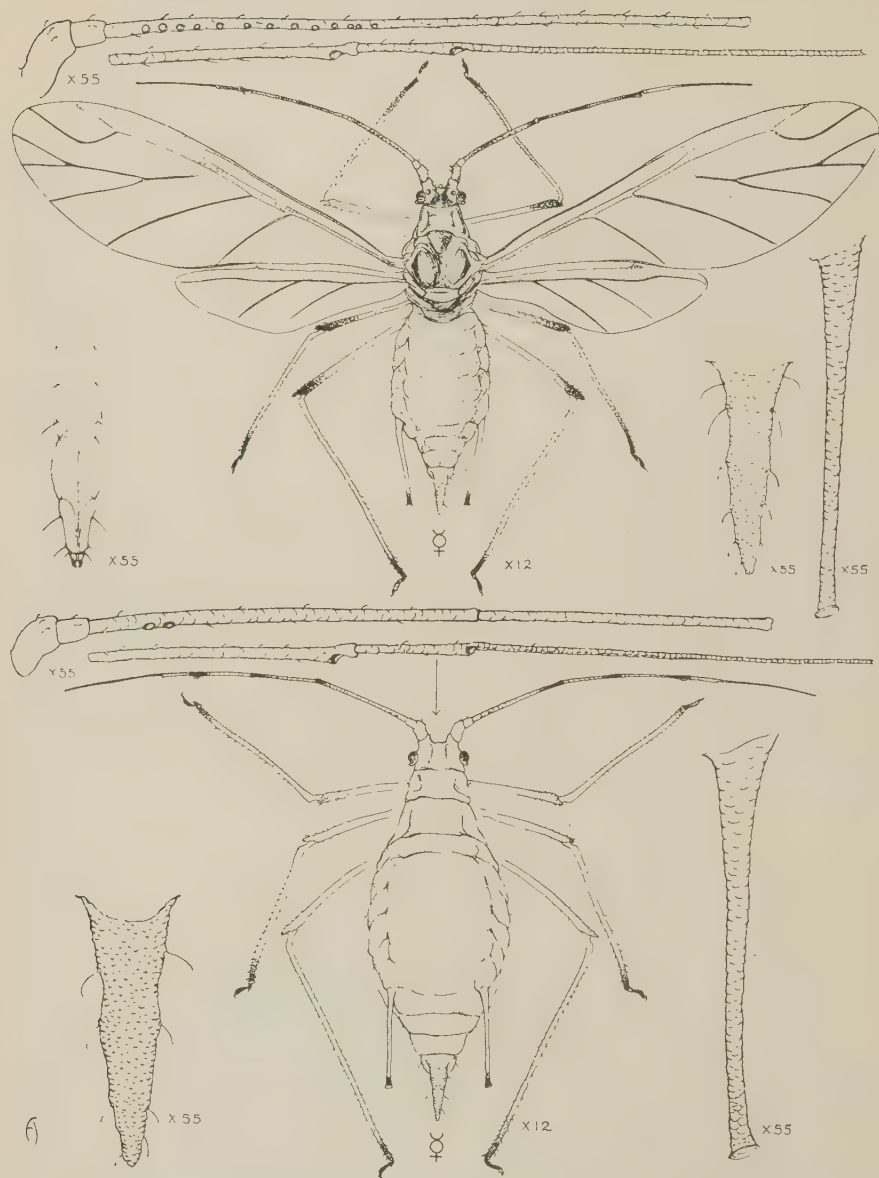


Fig. 1.—The pea aphid, *Macrosiphum pisi* (Kaltenbach): alate and apterous females with enlargements of the antennae, caudas, cornicles, and rostrum. (Enlargements indicated. Drawings by Frieda Abernathy).

insecticides. Among the many references to this destructive pest, the most important are Pergande (1904, p. 21-23), Davis (1915), and Soliman (1927, p. 132-33).

C. D. Harrington (1941, p. 461-66) has shown that a number of more or less distinct strains of the pea aphid occur in various parts of the country. Members of these strains may vary considerably in size, reproductive capacities, rate of development, destructiveness to the host plants, and resistance to insecticides. The adult apterous parthenogenetic females may attain a length of 2.5 to 3.5 mm.

In California the pea aphid is not known to produce sexual forms, although the latter may occur at higher altitudes of the Sierra Nevada. The aphid continues throughout the entire year as parthenogenetic apterous and alate females. During the winter, adults hibernate or may continue to reproduce young on perennial hosts. During the spring, summer, and fall, many generations are born and very large populations may occur in any month of the year. The greatest numbers appear in early spring and continue abundant until midsummer.

Nomenclature. Some authors believe that Schrank's name, *ulmariae*, should supersede *pisi* as the specific name. But the original description by Schrank seems to indicate that *ulmariae* is not synonymous with *pisi* Kalt. His statements that the antennae are shorter than half the length of the body and that the cornicles (*Scftspitzen*) are longer than the very short cauda ("*Schwänzchen am After*") are certainly not characteristic of *pisi*, in which the antennae are as long as the body or longer and the cauda is conspicuously well developed.

Aphis onobrychis B. de Fonscolombe may well have precedence over all other specific names. *Macrosiphum onobrychis* B. de Fonse. is the name being used in the publications of the Imperial Institute, London, England. But the combination *Macrosiphum pisi* (Kalt.) has been used so extensively in entomological literature in North America that changing it seems unwise.

The genus *Adactynus* was erected by Rafinesque (1817, p. 18).

The genus *Illinoia* was erected by Wilson (1910b, p. 318) for this species but has not been generally adopted. It has precedence over *Metopcurum* Mordvilko (1914, p. 56, 67) and *Acyrtosiphon* Mordvilko (1914, p. 55, 62).

The generic name *Acyrtosiphon* has been extensively used for the pea aphid in Europe and by some American authors. The long array of names now being given to this insect indicates the need of greater attention to these matters by national and international commissions of nomenclature.

Distribution. The pea aphid has been reported from all of the continents and is widely distributed throughout the world wherever food plants are available.

It occurs in every state in this country and in all the provinces of Canada. Its powers of flight are great and it often swarms in tremendous numbers and is carried long distances by air currents during the night as well as the day, especially in warm summer weather.

Host Plants. Although the preferred host plants are confined to the single family, Leguminosae, the members of this plant group are so extremely numerous that they cover much of the habitable areas of the world. Many of

the host plants produce valuable crops for man and his domestic animals. The injuries caused by the pea aphid may result in great loss to these crops and even complete failure. Such injuries may result from the aphid's feeding on and actually stunting or killing the plant or from the aphid's inoculating the hosts with virus diseases which may weaken or completely destroy the plants. Plants, other than legumes, are frequently listed as hosts of the pea aphid. The adults or young may feed on some of those plants and thus transmit a virus disease. However, rearing of the young is usually impossible on the non-leguminous hosts, and on many of these plants the insect may be only a casual visitor.

The pea aphid may be able to feed intermittently on violets and pansies as well as upon many other plants. The feeding in itself is not injurious; the damage the aphid does to these hosts is to infect them with the virus disease which may destroy them.

The pea aphid was reported from *Viola* by Swain (1919, p. 176) and Patch (1938, p. 181). As already pointed out, however, this aphid is a strong traveler, both on foot and on the wing, and is a casual visitor on many plants upon which it may not actually feed.

A complete list of the known host plants follows:

<i>Alhagi maurorum</i>	<i>Lupinus</i> spp.	<i>Trifolium hybridum</i>
<i>Capsella bursa-pastoris</i>	<i>Medicago falcata</i>	<i>Trifolium incarnatum</i>
<i>Celastrus scandens</i>	<i>Medicago hispida</i>	<i>Trifolium pratense</i>
<i>Clanthus puniceus</i>	<i>Medicago lupulina</i>	<i>Trifolium procumbens</i>
<i>Colutea arborescens</i>	<i>Medicago sativa</i>	<i>Trifolium repens</i>
<i>Cytisus scoparius</i>	<i>Melilotus alba</i>	<i>Trifolium scabrum</i>
<i>Genista tinctoria</i>	<i>Melilotus indica</i>	<i>Trigonella foenum-graecum</i>
<i>Glycine soja</i>	<i>Melilotus officinalis</i>	<i>Vicia americana</i>
<i>Igatum janium</i>	<i>Onobrychis viciaefolia</i>	<i>Vicia amoena</i>
(<i>Ignatia?</i>)	(<i>O. sativa</i>)	<i>Vicia atropurpurea</i>
<i>Lathyrus hirsutus</i>	<i>Ononis repens</i>	<i>Vicia angustifolia</i>
<i>Lathyrus latifolius</i>	<i>Peganum harmala</i>	<i>Vicia cracca</i>
(<i>L. angustifolius</i>)	<i>Phaseolus vulgaris</i>	<i>Vicia faba</i>
<i>Lathyrus maritimus</i>	<i>Pisum sativum</i>	<i>Vicia gigantea</i>
<i>Lathyrus odoratus</i>	<i>Pisum sativum</i> var. <i>arvense</i>	<i>Vicia ludoviciana</i>
<i>Lathyrus pisiformis</i>	(<i>P. arvense</i>)	<i>Vicia sativa</i>
<i>Lathyrus pratensis</i>	<i>Psoralea macrostachya</i>	<i>Vicia sepium</i>
<i>Lathyrus sativus</i>	<i>Robinia pseudoacacia</i>	<i>Vicia villosa</i>
<i>Lathyrus sylvestris</i>	<i>Trifolium agrarium</i>	<i>Vigna sinensis</i>
<i>Lespedeza cytoides</i>	<i>Trifolium alexandrinum</i>	<i>Viola</i> spp., (casual?)
<i>Lotus corniculatus</i>	<i>Trifolium arvense</i>	<i>Zizia aurea</i>
<i>Lotus oblongifolius</i>	<i>Trifolium filiforme</i>	

THE COTTON OR MELON APHID

Aphis gossypii Glover

The cotton or melon aphid, *Aphis gossypii* Glover, is a prolific, widely distributed, and omnivorous species, which is responsible for transmitting many mosaic and virus diseases of plants. It is very common and abundant throughout much of California and is widely distributed in the United States. It also occurs abundantly in the tropics.

This aphid is fully discussed in a previous paper (Essig, 1938a, p. 468-70). It is a small species, often blackish or very dark olive green in color, but frequently pale white, yellow, orange, or green, on different host plants.

Distribution. The cotton aphid has been recorded from the following countries:

Africa: Algeria, Anglo-Egyptian Sudan, Belgian Congo, British Togoland, Portuguese East Africa, Egypt, Eritrea, French West Africa, Italian Somaliland, Morocco, Nigeria, Nyasaland, Rhodesia, South Africa, Tanganyika Territory, and Uganda.

Asia: Armenia, Asiatic Russia, Astrakhan, Ceylon, China, India, Japan, Malaya, Palestine, Pescadores Islands, Syria, Taiwan, Transcaucasia, and Turkestan.

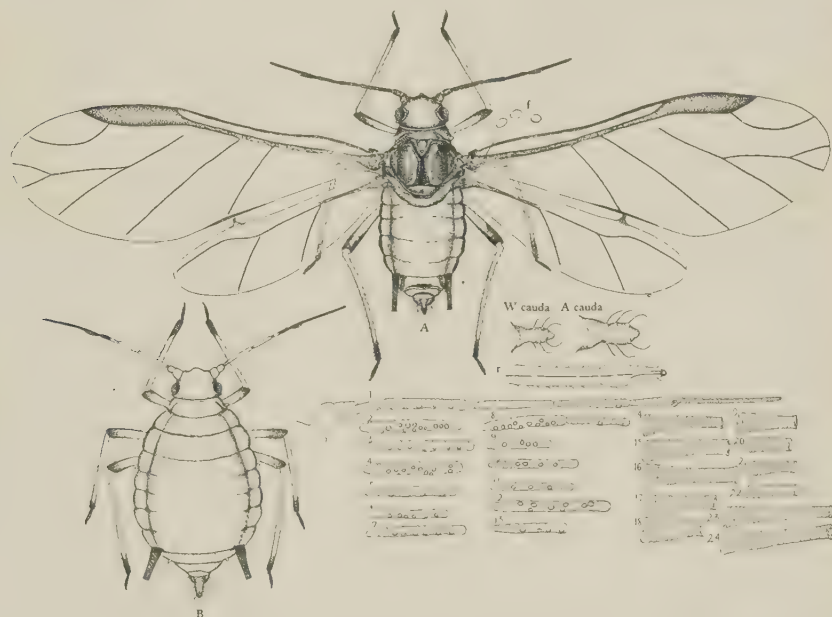


Fig. 2.—The cotton or melon aphid, *Aphis gossypii* Glover: A, winged viviparous female; B, apterous viviparous female; W cauda, cauda of winged female; A cauda, cauda of apterous female; f, fenestras; r, rostrum, 1, antenna of winged female on cotton, California; 2-13, antennal segment III of winged female drawn to scale to show variation in number of secondary sensoria and length. (All greatly enlarged.)

Europe: Belgium, Crimea, Cyprus, Denmark, France, Germany, Great Britain, Italy, Netherlands, U.S.S.R., Sweden, Switzerland.

Central America: Canal Zone, Panama.

North America: Bermuda, Canada, Mexico, United States, West Indies (Cuba, Jamaica, Puerto Rico).

South America: Argentina, Brazil, British Guiana, Chile, Dutch Guiana, Paraguay, Peru, Trinidad Island.

Oceania and the Pacific: Australia, Dutch East Indies, Fiji, Guam, Hawaii, Philippine Islands, Samoa.

In California it is found abundantly throughout the state except in high altitudes above 6,000 feet.

Host Plants. The cotton aphid is an omnivorous feeder, being specially destructive to cacao, citrus, cotton, cucumbers, melons, squashes, hibiscus, lilies, and many other plants. A complete list of host plants follows:

<i>Abutilon theophrastii</i>	<i>Calophyllum inophyllum</i>	<i>Cucumis sativus</i>
<i>Acalypha boemerioides</i>	<i>Canna</i> sp.	<i>Cucurbita maxima</i>
<i>Acalypha virginica</i>	<i>Capsella bursa-pastoris</i>	<i>Cucurbita meloriticulatus</i> (?)
<i>Acanthopanax trifoliatum</i>	<i>Capsicum frutescens</i>	<i>Cucurbita moschata</i>
(<i>A. aculeatus</i>)	(<i>C. annuum</i>)	<i>Cucurbita pepo</i>
<i>Acanthus ilicifolius</i>	<i>Capsicum dulce</i>	<i>Cuphea micropetala</i>
<i>Ageratum conyzoides</i>	<i>Cassia tora</i>	<i>Cyclamen europaeum</i>
<i>Allium cepa</i>	<i>Casuarina equisetifolia</i>	<i>Cyclamen indicum</i>
<i>Althaea nudiflora</i>	<i>Catalpa</i> sp.	<i>Cynometra ramiflora</i>
<i>Althaea officinalis</i>	<i>Ceiba pentandra</i>	(<i>C. cauliflora</i>)
<i>Althaea rosea</i>	(<i>Eriodendron anfractuosum</i>)	<i>Cyphomandra betacea</i>
<i>Amaranthus viridis</i>		<i>Datura stramonium</i>
<i>Ambrosia</i> sp.	<i>Cereus</i> sp.	<i>Delphinium</i> sp.
<i>Annona muricata</i>	<i>Cestrum diurnum</i>	<i>Dentella repens</i>
<i>Anthemis</i> sp.	<i>Chaenomeles japonica</i>	<i>Dianthus</i> sp.
<i>Antirrhinum</i> spp.	(<i>Pyrus japonica</i>)	<i>Dichrocephala latifolia</i>
<i>Antigonon leptopus</i>	<i>Chenopodium album</i>	<i>Diervilla</i> sp.
<i>Aphelandra pectinata</i>	<i>Chenopodium anthelminticum</i>	<i>Diodia teres</i>
<i>Apium graveolens</i>	<i>Chrysanthemum frutescens</i>	<i>Dipcadi serotina</i>
<i>Aquilegia vulgaris</i>	<i>Chrysanthemum morifolium</i>	<i>Dodartia</i> sp.
<i>Arabidopsis thaliana</i>	(<i>C. hortorum</i> ,	<i>Dolichos lablab</i>
<i>Arabis drummondii</i>	<i>C. sinensis</i>)	<i>Duranta repens</i>
<i>Arctium lappa</i>	<i>Chrysobalanus oblongifolius</i>	(<i>D. plumieri</i>)
<i>Ardisia esculenta</i>	<i>Cineraria</i> sp. (<i>Senecio</i> ?)	<i>Echinocystis fabacea</i>
<i>Aristolochia indica</i>	<i>Cirsium arvense</i>	<i>Echinocystis lobata</i>
<i>Asclepias mexicana</i>	<i>Citrullus vulgaris</i>	<i>Echeveria</i> spp.
<i>Asclepias speciosa</i>	<i>Citrus aurantium</i>	<i>Eclipta erecta</i>
<i>Asclepias verticillata</i>	<i>Citrus limonia</i>	<i>Elephantopus scaber</i>
<i>Asclepias vestita</i>	<i>Clerodendrum thomsoniae</i>	(<i>E. mollis</i>)
<i>Asparagus officinalis</i>	<i>Clerodendrum trichotomum</i>	<i>Erechtites praealta</i>
<i>Atriplex</i> sp.	<i>Clitoria</i> sp.	<i>Erechtites hieracifolia</i>
<i>Avena fatua</i>	<i>Coccolobis flendana</i>	<i>Erechtites valerianaefolia</i>
<i>Bauhinia variegata</i>	<i>Coccolobis floridana</i>	<i>Eriobotrya deflexa</i>
<i>Begonia semperflorens</i>	(<i>C. laurifolia</i>)	<i>Eriobotrya japonica</i>
<i>Benincasa hispida</i>	<i>Colocasia antiquorum</i>	<i>Erodium cicutarium</i>
<i>Beta vulgaris</i>	<i>Colocasia esculenta</i>	<i>Eucalyptus cladocalyx</i>
<i>Bidens frondosa</i>	<i>Colocasia kotoensis</i>	(<i>E. corynocalyx</i>)
<i>Bidens pilosa</i>	<i>Combretum apiculatum</i>	<i>Eucalyptus globulus</i>
<i>Blumea balsamifera</i>	<i>Commelina diffusa</i>	<i>Eugenia aquea</i>
<i>Boerhaavia plumbaginea</i>	<i>Commelina persicariaefolia</i>	<i>Euphorbia pilulifera</i>
(<i>B. viscosa</i>)	(<i>C. benghalensis</i>)	<i>Ficus benjamina</i>
<i>Borago officinalis</i>	<i>Cordia myxa</i>	<i>Ficus capensis</i>
<i>Bougainvillea spectabilis</i>	<i>Cornus mas</i>	<i>Ficus elastica</i>
<i>Brassica</i> (all species)	<i>Cosmia</i> sp. (<i>Cosmos</i> sp.)	<i>Flemingia congesta</i>
<i>Breynia officinalis</i>	<i>Cosmos caudatus</i>	<i>Forsythia viridissima</i>
<i>Brunnera macrophylla</i>	<i>Crataegus</i> spp.	<i>Fragaria chiloensis</i>
<i>Buddleia officinalis</i>	<i>Crocus dosdell</i>	<i>Fuchsia</i> spp.
<i>Bursera simaruba</i>	<i>Crotalaria anagyroides</i>	<i>Galinsoga</i> sp.
<i>Caladium</i> sp.	<i>Crotalaria mucronata</i>	<i>Galium circaeazans</i>
<i>Callicarpa dichotoma</i>	(<i>C. striata</i>)	<i>Gardenia jasminoides</i>
(<i>C. purpurea</i>)	<i>Cryptostegia grandiflora</i>	(<i>G. florida</i>)
<i>Callicarpa formosana</i>	<i>Cucumis citrullus</i>	<i>Gladiolus haltes</i>
<i>Callistephus chinensis</i>	<i>Cucumis melo</i>	<i>Glycine max</i> (<i>G. soja</i>)

<i>Gnaphalium japonicum</i>	<i>Malus domestica</i>	<i>Psidium guacum</i>
<i>Gnaphalium spathulatum</i>	(<i>Pyrus malus</i>)	<i>Psidium guajava</i>
<i>Gossypium herbaceum</i>	<i>Malva alcea</i>	<i>Punica granatum</i>
<i>Gossypium hirsutum</i>	<i>Malva parviflora</i>	<i>Pyrus communis</i>
<i>Helenium autumnale</i>	<i>Malva rotundifolia</i>	<i>Pyrus pyrifolia</i>
<i>Helianthus annuus</i>	<i>Malva sylvestris</i>	(<i>P. serotina</i>)
<i>Heliotropium indicum</i>	<i>Malvastrum fasciculatum</i>	<i>Raphiolepis</i> sp.
<i>Heptapleurum venulosum</i>	<i>Mammea americana</i>	<i>Rhamnus purshiana</i>
<i>Hibiscus abelmoschus</i>	<i>Mangifera indica</i>	<i>Rhapis excelsa</i>
(<i>H. moschatus</i>)	<i>Medicago sativa</i>	<i>Richardia scabra</i>
<i>Hibiscus eretveldaenuss</i>	<i>Melastoma candidum</i>	<i>Rosa</i> sp.
<i>Hibiscus esculentus</i>	<i>Melilotus alba</i>	<i>Ruellia difformis</i>
<i>Hibiscus rosa-sinensis</i>	<i>Melochia corchorifolia</i>	(<i>Hygrophila difformis</i>)
<i>Hibiscus sabdariffa</i>	(<i>Riedlea corchorifolia</i>)	<i>Rumex acetosella</i>
(<i>H. suddariffa</i>)	<i>Melothria maderaspatana</i>	<i>Rumex crispus</i>
<i>Hibiscus syriacus</i>	<i>Mentha spicata</i>	<i>Sagittaria latifolia</i>
<i>Hibiscus tiliaceus</i>	(<i>M. viridis</i>)	<i>Salix</i> sp.
<i>Hibiscus trionum</i>	<i>Mentzelia lindleyi</i>	<i>Salsola kali</i>
<i>Hoffmannia</i> sp.	(<i>Bartonia aurea</i>)	<i>Salvia scapiformis</i>
<i>Humulus lupulus</i>	<i>Monarda fistulosa</i>	<i>Salvia splendens</i>
<i>Hydrangea</i> sp.	<i>Morinda</i> sp.	<i>Satureia vulgaris</i>
<i>Hydrocotyle prolifera</i>	<i>Mosla formosana</i>	<i>Saxifraga splendens</i>
<i>Impatiens</i> spp.	<i>Nasturtium indicum</i>	<i>Scutellaria multiglandulosa</i>
<i>Ipomoea batatas</i>	<i>Nemesia strumosa</i>	<i>Sedum purpureum</i>
<i>Ipomoea pandurata</i>	<i>Nepeta hederacea</i>	(<i>S. telephium</i> ?)
<i>Ixora chinensis</i>	(<i>N. glechoma</i>)	<i>Sedum reflexum</i>
<i>Lactuca debilis</i>	<i>Nicotiana tabacum</i>	<i>Sempervivum</i> sp.
<i>Lactuca sativa</i>	<i>Nymphaea</i> spp.	<i>Senecio cruentus</i>
<i>Lagenaria siceraria</i>	<i>Ochroma pyramidale</i>	<i>Senecio mikanioides</i>
(<i>L. vulgaris</i>)	(<i>O. lagopus</i>)	<i>Senecio vulgaris</i>
<i>Lantana camara</i>	<i>Ocimum basilicum</i>	<i>Sesamum orientale</i>
<i>Lantana montevidensis</i>	<i>Oenothera biennis</i>	(<i>S. indicum</i>)
(<i>L. sellowiana</i>)	<i>Oldenlandia</i> sp.	<i>Sida acuta</i>
<i>Lawsonia inermis</i>	<i>Orobanche aegyptica</i>	<i>Solanum aculeatissimum</i>
<i>Leonurus sibiricus</i>	<i>Ourouparia formosana</i>	<i>Solanum melongena</i>
<i>Leontodon autumnalis</i>	(<i>Uncaria</i> sp.)	<i>Solanum nigrum</i>
<i>Lepidium virginicum</i>	<i>Passiflora</i> sp.	<i>Solanum seafortianum</i>
<i>Leucas lavandulaefolia</i>	<i>Perilla ocymoides</i>	<i>Solanum torvum</i>
<i>Leucas zeylanica</i>	<i>Persea americana</i>	<i>Solanum tuberosum</i>
<i>Lilium candidum</i>	(<i>P. persea</i>)	<i>Solanum verbascifolium</i>
<i>Lilium formosanum</i>	<i>Petasites japonicus</i>	<i>Sonchus oleraceus</i>
<i>Lilium longiflorum</i>	<i>Petunia</i> sp.	<i>Sophia</i> sp. (<i>Sisymbrium</i>
<i>Lilium regale</i>	<i>Phacelia californica</i>	sp.? <i>Pachira</i> sp.)
<i>Lilium speciosum</i>	<i>Phaseolus coccineus</i>	<i>Spathodea campanulata</i>
<i>Lilium testaceum</i>	<i>Phaseolus nanus</i>	<i>Spergula arvensis</i>
<i>Liquidambar formosana</i>	<i>Phaseolus vulgaris</i>	<i>Sphaeranthus</i> sp.
<i>Lonicera</i> spp.	<i>Philadelphus coronarius</i>	<i>Spinacia oleracea</i>
<i>Loranthus</i> sp.	<i>Piper nigrum</i>	<i>Stellaria media</i>
<i>Luffa acutangula</i>	<i>Pittosporum rhombifolium</i>	<i>Strychnos spinosa</i>
<i>Lycopersicon esculentum</i>	<i>Pittosporum tobira</i>	<i>Taraxacum officinale</i>
(<i>Solanum lycopersicum</i>)	<i>Plerocarpa mutica</i>	(<i>T. dens-leonis</i>)
<i>Lysimachia clethroides</i>	<i>Portulaca americana</i>	<i>Tectona grandis</i>
<i>Lysimachia stricta</i>	<i>Portulaca oleracea</i>	<i>Tephrosia candida</i>
<i>Magnolia</i> sp.	<i>Potentilla sylvestris</i>	<i>Tephrosia vogelii</i>
<i>Malpighia</i> sp.	<i>Pourthiaea villosa</i>	<i>Theobroma cacao</i>
<i>Malus coronaria</i>	<i>Pouzolzia indica</i>	<i>Tighonia grandiflora</i>
(<i>Pyrus coronaria</i>)	<i>Prunus</i> sp.	<i>Tribulus terrestris</i>

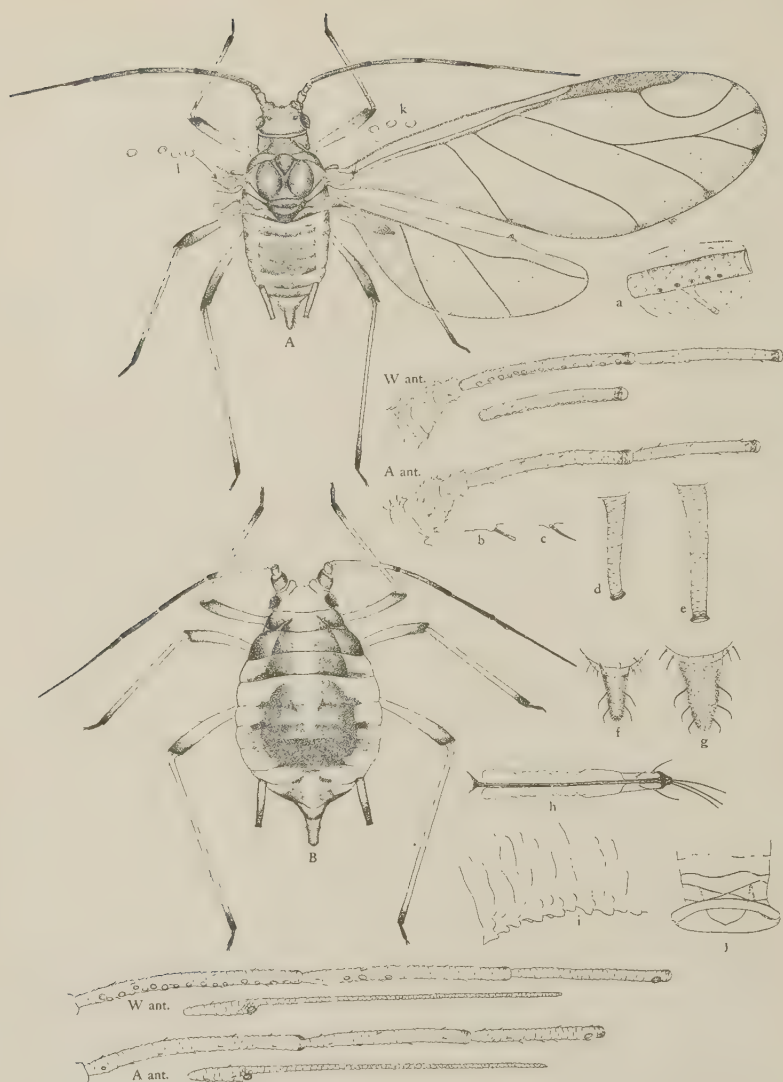


Fig. 3.—The lily aphid, *Myzus circumflexus* (Buckton): *A*, adult winged female: *a*, section of the costal vein showing fenestralike areas; *d*, cornicle; *f*, cauda; *k* and *l*, fenestras near the base of the subcostal vein; *W ant.*, antennae; *B*, adult apterous female: *A ant.*, antennae; *b* and *c*, setae on segments I and III of antenna; *e*, cornicle; *g*, cauda; *h*, rostrum; *i*, basal margin of cornicle; *j*, tip of cornicle. (All greatly enlarged.)

<i>Trifolium pratense</i>	<i>Veronica chinensis</i>	<i>Wisteria floribunda</i>
<i>Tulipa</i> sp.	<i>Veronica officinalis</i>	<i>Wisteria sinensis</i>
<i>Urena lobata</i>	<i>Veronica serpyllifolia</i>	<i>Wisteria macrostachya</i>
<i>Valeriana urticaefolia</i>	<i>Vinca major</i>	<i>Wisteria venusta</i>
(<i>V. valericaefolia</i>)	<i>Vinca minor</i>	<i>Zea mays</i>
<i>Verbena bipinnatifida</i>	<i>Viola odorata</i>	<i>Zinnia</i> sp.
<i>Verbena bracteata</i>	<i>Vitex trifolia</i>	
<i>Verbena hortensis</i>	<i>Vitis vinifera</i>	
(<i>V. hybrida</i>)	<i>Wedelia</i> sp.	

THE LILY APHID

Myzus circumflexus (Buckton) ,

Siphonophora circumflexa Buckton (1876, p. 130)

The lily aphid is a common species in greenhouses throughout the country. It also occurs outdoors along the coast of California. It feeds and propagates on a wide variety of plants, on which it sometimes produces dense colonies, although it shows decided preferences for members of the family Liliaceae. The aphids are pale yellow, the alates being partly black, whereas the apterae often have distinct black or dusky patches on the dorsum as shown in figure 3. An extensive treatment of this species is given in a previous paper (Essig, 1938a).

Distribution. This aphid has been widely distributed, in commerce, on bulbs and ornamentals. At the present time it is known to occur in the following continents, countries, and states:

Asia: Japan.

Europe: England, Wales, Holland, Russia, Sweden, Switzerland.

North America: Canada; United States, in California, Colorado, Indiana, Illinois, Maine, Michigan, New York, Oregon, Utah, Wisconsin, and possibly in many other states not yet reported.

South America: Argentina.

Pacific: Java, Hawaii.

Host Plants. The lily aphid has been recorded from the following plants:

<i>Adiantum curreatum</i>	<i>Avena</i> sp.	<i>Diospyros</i> sp.
(<i>A. cuneatum</i> ?)	<i>Bixa orellana</i>	<i>Eichhornia crassipes</i>
<i>Aesculus californica</i>	<i>Brunnera macrophylla</i>	<i>Ficus</i> sp.
<i>Alisma</i> sp.	(<i>Anchusa myosotidi-</i>	<i>Freesia refracta</i>
<i>Alopecurus pratensis</i>	flora)	<i>Fuchsia</i> spp.
<i>Anemone cylindrica</i>	<i>Caladium</i> sp.	<i>Geranium</i> sp.
<i>Antholyza refracta</i>	<i>Calceolaria europaeum</i>	<i>Gladiolus</i> sp.
<i>Anthurium</i> sp.	<i>Calendula officinalis</i>	<i>Hedera helix</i>
<i>Apium graveolens</i>	<i>Carduus</i> spp.	<i>Heliotropium laevis</i>
<i>Aquilegia canadensis</i>	<i>Ceanothus</i> sp.	<i>Heliotropium arborescens</i>
<i>Aquilegia canadensis</i>	<i>Cerastium viscosum</i>	(<i>H. peruvianum</i>)
var. <i>flavescens</i>	<i>Cheiranthus cheiri</i>	<i>Hordeum</i> sp.
<i>Arabis</i> sp.	<i>Chrysanthemum</i> sp.	<i>Hydrangea</i> sp.
<i>Artemisia dracunculus</i>	<i>Crocus</i> sp.	<i>Hydrocotyle prolifera</i>
<i>Arum</i> sp.	<i>Cyclamen europaeum</i>	<i>Ipomoea maxima</i>
<i>Asparagus plumosus</i>	<i>Cyclamen indicum</i>	<i>Iris</i> spp.
<i>Aster dracunculoides</i>	(<i>C. persicum</i>)	<i>Lilium elegans</i>
<i>Aster dumosus</i>	<i>Cyrtomium</i> sp.	<i>Lilium speciosum</i>
<i>Aster multiflorus</i>	<i>Dahlia</i> sp.	<i>Lycium</i> sp.
(<i>A. multiflorus</i> ?)	<i>Digitalis</i> sp.	<i>Lycopersicon</i> sp.



Fig. 4.—The foxglove aphid, *Myzus solani* (Kaltenbach), adult winged female; *W ant. iii*, antennal segment iii; *e*, corium of the abdomen; *A ant. iii*, antennal segment iii of apterous female; *a*, cornicle of apterous female; *b*, cauda of apterous female. (All greatly enlarged.)

<i>Malvastrum coccineum</i>	<i>Rudbeckia laciniata</i>	<i>Spiraea</i> sp.
<i>Myosotis</i> sp.	var. <i>hortensia</i>	<i>Stachys</i> sp.
<i>Myrtus</i> sp.	<i>Rumex</i> sp.	<i>Steironema lanceolatum</i>
<i>Nasturtium officinale</i>	<i>Sambucus</i> sp.	<i>Symphoricarpos albus</i>
<i>Nicotiana</i> sp.	<i>Schizanthus</i> sp.	<i>Streptocarpus</i> sp.
<i>Orchis</i> sp.	<i>Senecio cineraria</i>	(<i>S. racemosus</i>)
<i>Oxalis</i> sp.	<i>Senecio cruentus</i>	<i>Tradescantia fluminensis</i>
<i>Parthenocissa quinquefolia</i>	(<i>Doronicum cruentum</i>)	<i>Trifolium pratense</i>
<i>Penstemon spectabilis</i>	<i>Senecio mikanioides</i>	<i>Triticum vulgare</i>
<i>Persea</i> sp.	<i>Senecio renifolius</i>	<i>Tropaeolum</i> sp.
<i>Physalis peruviana</i>	(<i>Cineraria renifolia</i>)	<i>Tulipa</i> spp.
<i>Plantago hirtella</i>	<i>Senecio tenuifolius</i>	<i>Umbellularia californica</i>
<i>Polymnia canadensis</i>	<i>Sinningia digitalifolia</i>	<i>Vicia faba</i> var. <i>equina</i>
<i>Ranunculus acris</i>	(<i>Gloxinia digitalifolia</i>)	<i>Vinca major</i>
<i>Ribes aureum</i> var. <i>tenuiflorum</i>	<i>Sisymbrium officinale</i>	<i>Vinca minor</i>
<i>Rorippa nasturtium-</i> <i>aquaticum</i>	<i>Solanum nigrum</i>	<i>Viola nuttallii</i>
<i>Rosa</i> sp.	<i>Solanum tuberosum</i>	<i>Viola tricolor</i>
<i>Rudbeckia laciniata</i>	<i>Solidago missouriensis</i>	<i>Watsonia rosea</i>
	<i>Sparaxis</i> sp.	<i>Zantedeschia aethiopia</i>
		<i>Zantedeschia melanoleuca</i>

THE FOXGLOVE APHID

- Myzus solani* (Kaltenbach, 1843, p. 15-16)
Aulacorthum solani (Kaltenbach)
Myzus convolvuli (Kaltenbach)
Macrosiphum aucubae Bartholomew (1932, p. 723-25)
Myzus gei Theobald (1919, p. 157; 1926, p. 349-50)
Myzus glaucii Theobald (1923, p. 103; 1926, p. 330-31)
Myzus hydrocotylei Theobald (1925, p. 73; 1926, p. 334-35)
Macrosiphum matsumuraeanum Hori (1926, p. 52-83)
Myzus mercurialis Theobald (1919, p. 158; 1926, p. 350-51)
Myzus polyanthi Theobald (1926, p. 341)
Myzus piceacellus Theobald (1916, p. 146; 1926, p. 315-16)
Myzus primulana Matsumura (1917, p. 400-1)
Myzus pseudolamii Theobald (1915b, p. 274; 1926, p. 345-46)
Myzus pseudosolani Theobald (1926, p. 313-15)
Macrosiphum veronicae Theobald (1913, p. 93)
Myzus veronicellus Theobald (1926, p. 347-48)
Aphis vincae Walker (1848, p. 429)

The foxglove aphid was so designated by Patch (1928) because of its importance as a pest of the common foxglove, *Digitalis purpurea*, a European ornamental extensively cultivated throughout much of North America. Along the Pacific Coast, especially in northern California and Oregon, this plant has become naturalized and is regarded as a pest of some importance on grazing lands. In these areas this host plant affords an abundance of food for the aphid.

This aphid may be distinguished from its nearest relatives by its more than medium size; its long antennae, which are much longer than the body; the large wings extending well beyond the tip of the abdomen; the dark, broken, transverse bands on the dorsum of the abdomen of the alates; and the long, almost cylindrical cornicles, which have a few broken concentric rings or reticulations around the apices. The apices are well flared and dusky black.

The apterous forms are usually without markings, except that in mounted specimens two longitudinal rows of groups of small dorsal glands are often evident on the sides of the abdomen. The prevailing colors may vary from whitish and yellowish, to pale or dark green with dusky areas at tips of the paler antennal segments, the apices of the leg segments, and the tips of the cornicles. (See figs. 4 and 5.)

The species is variable in size and color, a characteristic which has caused considerable confusion among aphidologists and resulted in the large number



Fig. 5.—The foxglove aphid, *Myzus solani* (Kaltenbach), adult apterous female: a, tip of cornicle. Other details are shown in figure 5.

of synonyms. A fuller discussion of this aphid may be found in a previous paper (Essig, 1938a) and in one by Mason (1940).

Nomenclature. In recent years this aphid has been most often designated as *Myzus convolvuli* (Kalt.) and *Myzus solani* (Kalt.). The Imperial Institute of Entomology, London, has adopted *Macrosiphum solani*. This specific name has page precedence over *convolvuli* in Kaltenbach's work (1843, p. 15–16, 40–41). In this country the genus *Myzus* is preferred to *Macrosiphum* for this species.

The genus *Aulacorthum* was erected by Mordvilko in 1914 (1914, p. 68) and has been accepted for this species by Hille Ris Lambers and some other European aphidologists.

Myzus convolvuli (Kalt.) is the name that has been most frequently used for this aphid in North America. It has now been accepted as a synonym of *M. solani* (Kalt.) in Europe and by many in this country.

Distribution. The foxglove aphid is widely distributed in the temperate regions and occurs in greenhouses in even colder areas. It is reported from the following places:

Africa: Egypt.

Asia: China, Japan.

Europe: Belgium, England, France, and Italy.

North America: Canada, in British Columbia (Victoria) and Ontario (Vineland); United States, in California (Berkeley, Lagunitas, Lompoc, Los Angeles, Niles, Pepperwood, Point Reyes, Riverside, San Francisco, San Jose, Shafter, Stanford University, Ukiah, Ventura, Viehi Springs, Woodacre).

South Pacific: Territory of Hawaii (Hawaii, Oahu, and Maui).

Host Plants. The foxglove aphid is an omnivorous feeder and has been reported as feeding upon many hosts. Doubtless in some instances the insects were merely casuals which may have been only transitory visitors. The list compiled to date includes the following:

<i>Acer negundo</i>	<i>Erodium cicutarium</i>	<i>Mentha arvensis</i>
<i>Althaea</i> sp.	<i>Erodium moschatum</i>	var. <i>piperascens</i>
<i>Amaranthus</i> spp.	<i>Euphorbia boolceri</i>	<i>Mentzelia lindleyi</i>
<i>Ambrosia</i> sp.	<i>Fragaria</i> spp.	(<i>Bartonia aurca</i>)
<i>Anemone</i> sp.	<i>Fuchsia arborescens</i>	<i>Mimulus aurantiacus</i>
<i>Anthemis</i> sp.	<i>Galium verum</i>	(<i>Diplacus aurantiacus</i> ,
<i>Anthirrhinum</i> spp.	(<i>G. luteum</i>)	<i>D. glutinosus</i>)
<i>Apium graveolens</i>	<i>Geranium</i> spp.	<i>Musa paradisiaca</i>
<i>Aquilegia formosa</i>	(including <i>G. dissectum</i>)	<i>Nemophila heterophylla</i>
<i>Aretium lappa</i>	<i>Geum aleppicum</i> var. <i>structum</i>	<i>Oenothera</i> spp.
<i>Asarum</i> sp.	<i>Geum urbanum</i>	<i>Oxalis</i> spp.
<i>Asclepias</i> spp.	<i>Gladiolus</i> spp.	<i>Phalaenopsis</i> sp.
<i>Atropa belladonna</i>	<i>Glaucium flavium</i>	<i>Phaseolus angularis</i>
<i>Aucuba japonica</i>	(<i>G. luteum</i>)	<i>Phaseolus vulgaris</i>
<i>Auricula</i> sp.	<i>Glycine max</i>	<i>Physalis</i> sp.
(<i>Primula auricula</i> ?)	(<i>G. soja</i>)	<i>Picea abies</i> (<i>P. excelsa</i>)
<i>Begonia</i> spp.	<i>Gnaphalium</i> spp.	(casual?)
<i>Brassica</i> spp.	<i>Helianthus tuberosus</i>	<i>Pisum sativum</i>
<i>Capsella bursa-pastoris</i>	<i>Helichrysum</i> sp.	<i>Pittosporum</i> spp.
<i>Carum</i> spp.	<i>Hieracium lanatum</i>	<i>Plantago</i> sp.
<i>Castilleja latifolia</i>	<i>Hieracium aurantiacum</i>	<i>Portulaca</i> sp.
<i>Cestrum</i> spp.	<i>Hieracium mucorum</i>	<i>Potentilla</i> sp.
<i>Chenopodium album</i>	<i>Hydrangea</i> spp.	<i>Primula polyantha</i>
<i>Chrysanthemum</i> spp.	<i>Hydrocotyle vulgaris</i>	(<i>Polyanthus</i> sp.)
<i>Cineraria</i> spp.	<i>Hyoscyamus</i> sp.	<i>Primula sieboldii</i>
(<i>Senecio</i> spp.?)	<i>Hypochaeris</i> sp.	<i>Primula vulgaris</i>
<i>Citrus maxima</i>	<i>Ipomoea purpurea</i>	<i>Radicula curvisiliqua</i>
<i>Clintonia andrewsiana</i>	(<i>Convolvulus major</i>)	<i>Ranunculus</i> spp.
<i>Conium</i> spp.	<i>Lactuca sativa</i>	<i>Rubus hawaiiensis</i>
<i>Convolvulus sepium</i>	<i>Lamium purpureum</i>	<i>Rubus idaeus</i>
<i>Convolvulus tricolor</i>	<i>Lathyrus</i> spp.	<i>Rubus idaeus</i> var.
(<i>C. minor</i>)	<i>Leonotis leonurus</i>	<i>strigosus</i>
<i>Coprosma baueri</i>	<i>Lеспедеза bicolor</i>	<i>Rubus laciniatus</i>
<i>Crataegus</i> spp.	<i>Lilium</i> spp.	<i>Rumex acetosa</i>
<i>Crotalaria anagyroides</i>	<i>Lycopersicon esculentum</i>	<i>Rumex crispus</i>
<i>Cucurbita pepo</i>	<i>Lysimachia</i> sp.	<i>Santibucus racemosa</i>
<i>Digitalis purpurea</i>	<i>Malus communis</i>	<i>Sanicula menziesii</i>
<i>Epipactis gigantea</i>	(<i>M. sylvestris</i>)	<i>Senecio</i> spp.
<i>Eriodictyon californicum</i>	<i>Melilotus</i> spp.	<i>Solanum giganteum</i>

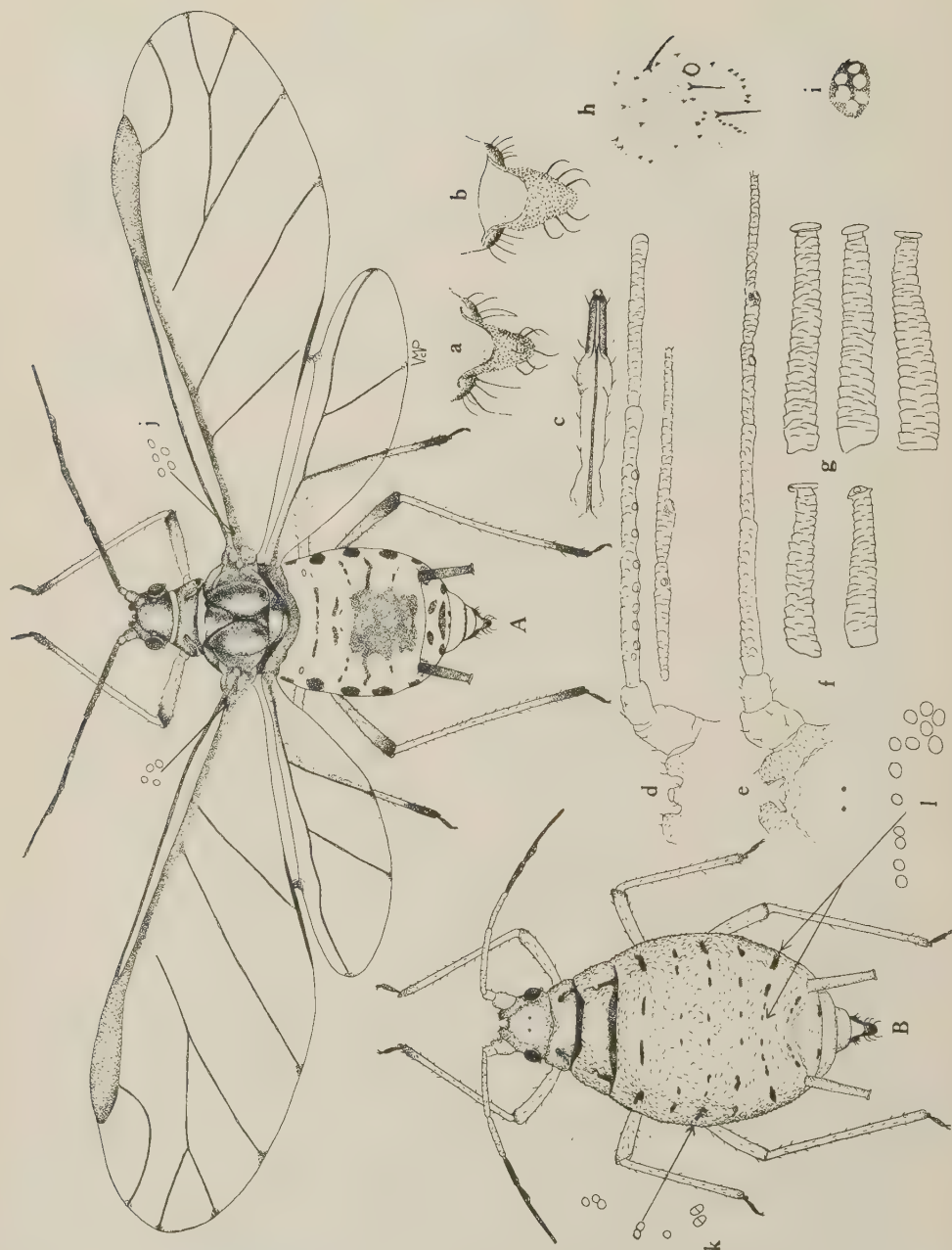


Fig. 6.—The ornate aphid, *Myzus ornatus* Laing: A, adult alate female; a, cauda; c, rostrum; d, front of head and antenna; f, cornicles; h, lateral abdominal dusky area; i, group of abdominal gland pores; j, fenestras near base of subcostal vein; B, adult apterous female; b, cauda; e, front of head and antenna; g, cornicles; l, gland pores arranged in dark broken bands on abdomen; k, lateral gland pores. (All greatly enlarged.) (From Pan-Pacific Entomologist 14:94, 1938.)

Solanum jasminoides
Solanum melongena
Solanum tuberosum
Solidago sp.
Sonchus spp.
Stachys ajugoides
Stachys bullata
Stachys californica
Stellaria media
Symphoricarpos albus

Tanacetum sp.
Taraxacum officinale
Trifolium incarnatum
Trifolium pratense
Trifolium repens
Ulmus sp.
Urtica dioica
Urtica gracilis
Verbascum sp.
Verbena sp.

Veronica beccabunga
Vinca major
Vinca minor
Viola spp.
Wisteria sinensis
Zantedeschia sp.
Zanthoxylum pterota
 (Z. *fagara*).

THE ORNATE APHID

Myzus ornatus Laing (1932, p. 52-53; Essig, 1938a, p. 92-95; Mason, 1940, p. 14-15)

The ornate aphid, *Myzus ornatus* Laing is very small and is quite easily recognized by the transverse, dusky, broken dark bands, on the dorsum of the apterae, as shown in figure 6. A more complete discussion of this aphid is given in a previous paper (Essig, 1938b).

Distribution. The ornate aphid is a newcomer in California, having first been taken in Berkeley, April 4, 1936, by the writer. It is rather widely distributed in Northern Europe. It was first reported in England in 1932 (Laing, 1932, p. 52-53). Since then it has been collected in Scotland, Ireland, and Belgium (Essig, 1938a). In 1941 it was discovered in New South Wales by Zeek (1941). In Honolulu, Hawaii, it was first collected in 1944 by E. C. Zimmerman, who also found it on the Island of Maui, 1945. In the United States it is now known to occur only in California and Oregon. In California it has been collected at Alton (H. T. Osborn), Berkeley (in greenhouses and outdoors, E. O. Essig), Lompoc (R. M. Bohart, K. F. Baker, W. C. Snyder), Los Angeles (R. H. Smith), and Sacramento (J. B. Steinweden); in Oregon, at Portland and Yachats (J. H. Schuh).

Host Plants. A list of known host plants follows:

Achyranthes spp.
Apium graveolens
 var. *dulce*
Artemisia vulgaris
Baccharis viminea
Bellis perennis
Brassica spp.
Buddleia orientalis
Calceolaria sp.
Camellia sp.
Capsicum frutescens
Chrysanthemum sp.
Cineraria sp.
 (Senecio sp.?)
Clematis sp.
Coleus sp.
Crepis virens
Crotalaria anagyroides
Dianthus barbatus
Digitalis purpurea
Dipsacus fullonum
Erodium sp.

Fragaria sp.
Fuchsia elegans
 (F. *globosa*?)
 F. *coccinea*?)
Geum urbanum
Hedera helix
Helenium peregrinum
Helianthemum sp.
Heliotropium arborescens
Hydrangea sp.
Ilex sp.
Lantana sp.
Lapsana communis
Loiseleuria procumbens
 (Azalea *procumbens*)
Malus communis
 (Pyrus *malus*)
Matricaria chamomilla
Medicago sativa
Nasturtium officinale
 (Roripa *nasturtium*)
Panax lancasteri

Pieris sp.
Plantago major
Potentilla sp.
Primula spp.
Ranunculus repens
Rheum rhaponticum
Richardia rehmanni
Rubus procerus
Rumex acetosella
Rumex obtusifolius
Salvia sp.
Scabiosa sp.
Taraxacum officinale
Teesdalia nudicaulis
Trifolium pratense
Ulmus procera
Urtica dioica
Valeriana sp.
Veronica spp.
Viola sp.

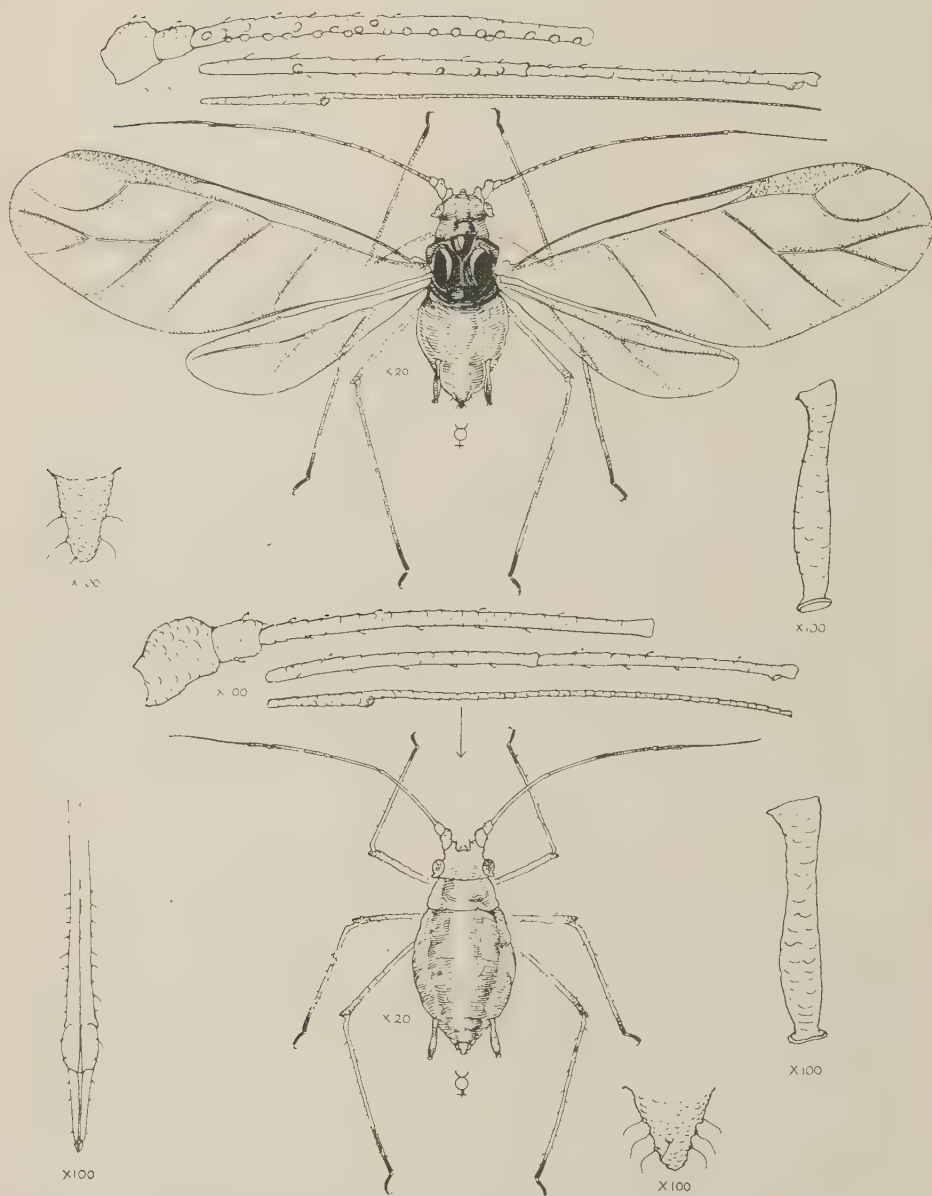


Fig. 7.—The violet aphid, *Micromyzus violae* (Pergande): winged female with antenna, cauda, and cornicle greatly enlarged; apterous female with antenna, rostrum, cauda, and cornicle. (All enlarged as indicated.) (Drawings by Frieda Abernathy.)

THE VIOLET APHID

Micromyzus violae (Pergande)

Rhopalosiphum violae Pergande (1900, p. 29-30)

Rhopalosiphum violae Essig (1909, p. 4-8)

Fullawayella violae (Pergande) Baker, 1919, p. 45-46; Takahashi, 1921, p. 29; Hardy, 1931, p. 34-35)

Neotoxoptera violae Theobald (1915a, p. 131-32; Baker, 1919, p. 45-46)

The violet aphid may at once be recognized by the pictured or cloudy wings and its very dark red, maroon, brownish, or even greenish-black body. The long antennae, slightly swollen cornicles, and short cauda also aid in separating it from other species infesting violets and pansies. It is slow and sluggish and appears to move only with considerable exertion. For more extended descriptions see Sanborn (1904, p. 64-65) and Essig (1935, p. 157). The winged and apterous females are shown in figure 7.

Nomenclature. Although this species has been shifted among at least four genera, the genus *Micromyzus* van der Goot (1916) now appears to be most logical.

The species *Rhopalosiphum violae* Essig was described without knowledge of Pergande's description. It is a synonym.

The genus *Neotoxoptera* was erected for what appears to be a variant of *Micromyzus violae* (Pergande). Specimens of this species frequently diverge from the type.

Distribution. The violet aphid has become widely distributed through commerce and now occurs in many parts of the subtropical and temperate regions where violets and pansies are cultivated or grow wild in the open. The aphid also abounds on the host plants grown in greenhouses or in other sheltered places. It has been reported from the following localities:

Africa: Onderstepoort, Transvaal.

Asia: Formosa.

Australia: Queensland.

North America: British Columbia; California (Claremont, Berkeley, Porterville, Riverside, Santa Ana, Santa Paula, Stanford University, Ventura), Connecticut, Illinois, Kansas, Mississippi, New Jersey, New Mexico, New York, and Washington.

Host Plants. The violet aphid feeds chiefly on the tender new growth of violets and pansies, including the leaves, leaf stems, and flowers; when abundant, it may occur on the entire plants and especially on the undersides of the leaves close to the ground. Infested plants often appear dwarfed, the foliage curled and sickly—no doubt the result of the virus diseases transmitted by the aphid. The only recorded host plants of this aphid are:

Lilium spp.

Mazus japonicus

Fiburnum sp.

Viola spp.—many, but apparently not all species, are infested.

Adult alates may be found resting on many other plants upon which young are not reared.

OTHER SPECIES OF APHIDS REPORTED AS FEEDING ON VIOLETS AND PANSIES

Species of aphids feeding on violets and pansies and on other members of the family Violaceae are not numerous. In addition to the species already discussed, the following aphids have also been reported by Patch (1928, p. 180-81) as feeding upon these plants:

The buckthorn aphid, *Aphis abbreviata* Patch, on *Viola tricolor*; Maine (Patch, 1924, p. 38). Patch has made this a synonym of *Aphis rhamni* Boyer de Fonscolombe (1841, p. 177).

Aphis certa Walker on *Viola tricolor* England (Theobald, 1929, p. 63).

Aphis malvae (Koch) on *Viola tricolor*; Lahore (Das, 1918, p. 273).

Aphis malvacearum v.d. Goot (= *A. malvoides* Das) on *Viola tricolor*; Lahore (Das, 1918, p. 273).

Aphis plantaginis Schrank on *Viola* sp.; England, Belgium, France, Germany, Italy (Theobald, 1927, p. 131).

Aphis violae Schouteden on *Viola tricolor*; Belgium (Schouteden, 1900, p. 127; 1906, p. 229).

Macrosiphum malvae (Mosely) on *Viola odorata* and *V. tricolor*; England and Italy (Maccchiati, 1883, p. 230; Theobald, 1926, p. 124). Theobald considers this species to be a synonym of *Macrosiphum pelargonii* (Kalt.). This latter species has so often been confused with *Myzus solani* (Kalt.) that it is possible *Macrosiphum malvae* may be a synonym of it.

The tulip leaf aphid, *Rhopalosiphoninus tulipella* (Theobald), on *Viola* sp.; England (Theobald, 1926, p. 222). This species has been found on tulip bulbs from Washington state (Essig collection, 1934), and alates resting on *Hesperis matronalis* at Corvallis, Oregon, April 15, 1941, by J. Schuh (Essig collection). It has been taken in quarantine on tulip bulbs from Holland (California State Department of Agriculture, March 6, 1945).

The green peach aphid, *Myzus persicae* (Sulzer), has been successfully used by H. H. P. Severin in transmitting celery calico to pansies. This insect does not appear to have been recorded as regularly feeding and reproducing on pansies and violas, although it has been listed on more than 200 host plants. It has been fully discussed by the author in a previous paper (Essig 1938a, p. 482-85).

Saltusaphis insessa Walker reported on *Viola* sp. by Walker in England, represents perhaps casual visitors on violets or an error (Theobald 1927, p. 199). This aphid was subsequently taken on *Juncus maritima* in England.

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